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Uniform Distribution Technique of Cluster Heads in LEACH Protocol

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***Abstract*—A sensor network is composed of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. Clustering provides an effective way for prolonging the lifetime of a wireless sensor network. Current clustering algorithms usually utilize two techniques, selecting cluster heads (CHs) with more residual energy and rotating cluster heads periodically, to distribute the energy consumption among nodes in each cluster and extend the network lifetime. LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network. But LEACH cannot select the cluster-heads uniformly throughout the network. Hence, some nodes in the network have to transmit their data very far to reach the CHs, causing the energy in the system to be large. Here we have an approach to address this problem for selecting CHs and their corresponding clusters. The goal of this paper is to build such a wireless sensor network in which each sensor node remains inside the transmission range of CHs and its lifetime is enlarged.**

***Index Terms*—BS- Base Station, CH- Cluster Head, LEACH-Low-Energy Adaptive Clustering Hierarchy, UDT- Uniform Distribution Technique, WSN- Wireless Sensor Network**

I. Introduction

Recent advances in wireless communications and electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks. Sensor networks represent a significant improvement over traditional sensors [4].A sensor network is consisting of a large number of sensor nodes and the position of sensor nodes need not be engineered or predetermined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an onboard processor. Instead of sending the raw data to the nodes responsible for the fusion, they use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data.The above-described features ensure a wide range of applications for sensor networks. Some of the application areas are health, military, and home.Despite the innumerable applications of WSNs, these networks have several restrictions, such as limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes. One of the main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation by employing aggressive energy management techniques. The design of routing protocols in WSNs is influenced by many challenging factors. These factors must be overcome before efficient communication can be achieved in WSNs.

The energy consumption of WSN can be reduced by allowing only a section of the nodes called cluster heads, to communicate with the base station. The data sent by each node is then collected by cluster heads and compressed. After that the aggregated data is transmitted to the base station. Although clustering can reduce energy consumption, the main problem is that energy consumption is concentrated on the cluster heads. The representative solution is LEACH [1], which is a localized clustering method based on a probability model. The main idea of LEACH protocol is that all nodes are chosen to be the cluster heads periodically.

II. Routing Protocol in WSN

In general, routing in WSNs can be divided into flat-based routing, hierarchical-based routing, and location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality. In hierarchical- based routing, nodes will play different roles in the network. In location-based routing, sensor nodes' positions are exploited to route data in the network [2]. The objective of the Energy-Aware Routing protocol [3], a destination- initiated reactive protocol, is to increase the network lifetime [2]. LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses localized coordination to enable scalability and robustness for dynamic networks, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station [1].LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. In LEACH, the nodes organize themselves into local clusters, with one node acting as the local base station or cluster-head. Sensors elect themselves to be local cluster-heads at any given time with a certain probability. These cluster head nodes broadcast their status to the other sensors in the network. Each sensor node determines to which cluster it wants to

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belong by choosing the cluster-head that requires the minimum communication energy. Once all the nodes are organized into clusters, each cluster-head creates LEACH outperforms static clustering algorithms by requiring nodes to volunteer to be high-energy cluster-heads and adapting the corresponding clusters based on the nodes that choose to be cluster-heads at a given time. A schedule assigned for the nodes in its cluster. Once the cluster-head has all the data from the nodes in its cluster, the cluster-head node aggregates the data and then transmits the compressed data to the base station.But there are several factors where this protocol still requires some up gradations: This protocol is solely built for small as well as homogeneous network. It causes extra overhead due to head changes and advertisements etc.

No uniform distribution techniques for predetermined CHs. It also assumes that nodes always have data to send, and nodes located close to each other have correlated data. It is not obvious how the number of predetermined CHs is going to be uniformly distributed through the network. Therefore, there is the possibility that the elected CHs will be concentrated in one part of the network; hence, some nodes in the network have to transmit their data very far to reach the CHs, causing the energy in the system to be large.

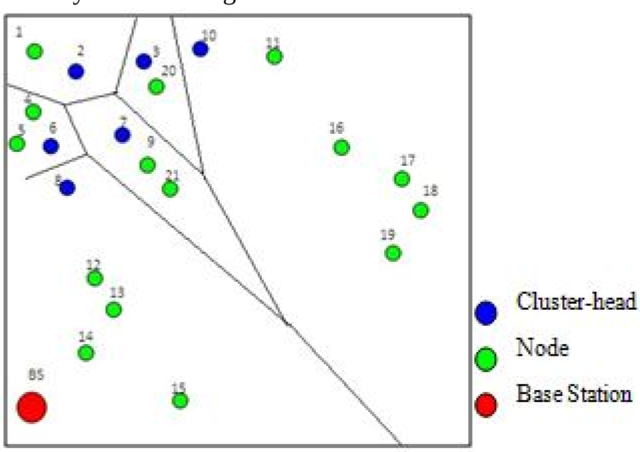

Fig. 1. Non-uniformed Cluster-Head Distribution.

In Fig. 1, there are six cluster-heads 2, 3, 6, 7, 8 and 10. Their coverage areas are shown. Each sensor node determines to which cluster it wants to belong by choosing the cluster-head closest to the sensor. In Fig. 1 CHs are concentrated in one part of the network; hence, some nodes in the network have to transmit their data very far to reach the CHs, causing the energy in the system to be large.For example, for sensor node 16, 17, 18, and 19 cluster-head 10 is closest but it is far enough, so nodes need to transmit their data very far to reach the CHs that cause large energy. Failure of a CH causes fail to the whole cluster. As nodes in a cluster have the only way to transmit data to the base station through cluster-head, failure of the CH vanishes the whole cluster. For example-In Fig. 1, if cluster-head 10 fails then node 11, 16, 17, 18 and 19 will be vanished from the network. When cluster heads cooperate with each other to forward their data to the base station, the cluster heads closer to the base station are burdened with heavy relay traffic and tend to die early, leaving areas of the network uncovered and causing network partition.There is another lack in LEACH which is no real timetransmission. As the node senses ever changing real life data, sensed data can be changed during the transmission latency from nodes to base station through cluster-head. Several recently proposed models have addressed on LEACH protocol. Energy-LEACH protocol improves the CH selection procedure. It makes residual energy of node as the main metric which decides whether the nodes turn into CH or not after the first round [5]. In Tow-Level LEACH protocol [6], CH collects data from other cluster members as original LEACH, but rather than transfer data to the BS directly, it uses one of the CHs that lies between the CH and the BS as a relay station. Multihop-LEACH protocol [7] selects optimal path between the CH and the BS through other CHs and use these CHs as a relay station to transmit data over through them. LEACH-C [8] uses a centralized clustering algorithm and the steady-state phase of LEACH-C is identical to that of the LEACH protocol.

In this paper, Section III presents our new energy-aware topology evolving model for wireless sensor networks. Finally, we conclude the investigation and point out the further research direction.

III. Uniform Distribution Technique of CHs

In this paper, we propose a Uniform Distribution Technique of Cluster heads in LEACH Protocol in wireless sensor networks. It wisely organizes the network through consistent distribution of clustering. LEACH Protocol works in the following steps [1]:

1. Decide cluster heads.
2. Broadcast advertisement.
3. Nodes transmit membership.
4. Heads broadcast schedule.
5. Nodes transmit data.
6. Heads compress data and send to base station.
7. New turn begins go to 1.

We can improve the limitation of uniform distribution of CHs, if the coverage area of each CH can be predefined before step 1. The CHs will be efficiently allocated throughout the network. Initially all nodes are homogeneous. The node, which has the maximum remaining energy, advertises itself as the first CH. Then the first CH selects an area, no other node in that particular area can advertise itself as CH. After that another CH is selected from rest of the network. In this way the whole network is divided into some predefined areas. Each area contains one CH and all the nodes in that area constructs a cluster. So, if the elected CHs concentrate in certain area of the network, then not a single node in the network have to transmit their data very far to reach the CHs, which cause the energy in the system to be large. Thus the CHs are uniformly distributed throughout the network. The selection of coverage area for a certain CH can be determined by selecting a circle using an Energy-Efficient Unequal Clustering Mechanism (EEUC) [1]. EEUC is a distributed cluster heads competitive algorithm, where cluster head selection is primarily based on the residual energy of each node. First, several tentative cluster heads are selected to compete for final cluster heads. Every node becomes a tentative cluster head with the same probability T that is a predefined threshold.

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Other nodes keep sleeping until the cluster head selection stage ends. Suppose s_i becomes a tentative cluster head. s_i has a competition range R_{comp}, which is a function of its distance to the base station. If s_i becomes a cluster head at the end of the competition, there will not be another cluster head *sj* withins_i's competition diameter. Fig. 2 illustrates a topology of tentative cluster heads, where the circles represent different competition ranges of tentative cluster heads. In Fig. 2 s_1 and s_2 can both be cluster heads, but s_3 and s_4 cannot.Therefore the distribution of cluster heads can be controlled over the network. And the cluster heads closer to the base station should support smaller cluster sizes because of higher energy consumption during the inter-cluster multihop forwarding communication. Thus more clusters should be produced closer to the base station. That is to say, the node's competition radius should decrease as its distance to the base station decreases. The range of competition radius in the network needs to be controlled [1]. Suppose, R^0_{comp} is the maximum competition radius, which is predefined. Setting R_{comp} of s_i as a function of its distance to the base station [1]:

$$s_i.R_{comp} = \left(1 - c\frac{d_{\max} - d(s_i, BS)}{d_{\max} - d_{\min}}\right)R^0{}_{comp} \qquad (1)$$

Where d_{max} and d_{min} denote the maximum and minimum distance between sensor nodes and the base station, $d\ (s_i, BS)$ is the distance between *si* and the base station, *c* is a constant coefficient between *0* and *1*. According to the equation, the competition radius varies from $(1 - c)\ R^0{}_{comp}$ to $R^0{}_{comp}$.Each tentative cluster head maintains a set S_{CH} of its "adjacent" tentative cluster heads. Tentative head s_j is an "adjacent" node of s_i if s_j is in s_i's competition diameter or s_i is in s_j's competition diameter [1]. Whether a tentative cluster head s_i will become a final cluster head depends on the nodes in S_{CH}.

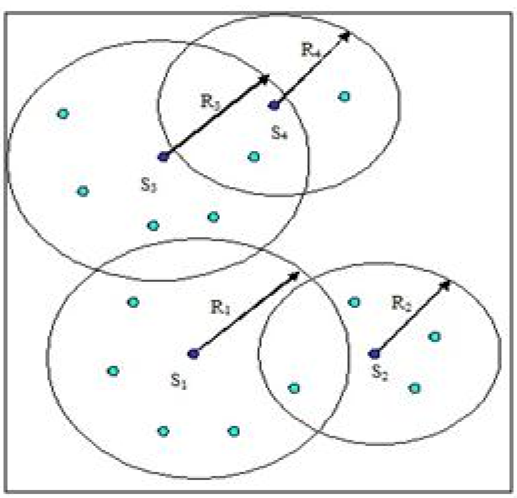

Fig. 2. The competition among tentative CHs.

Therefore our proposed approach to enhance the performance of Low Energy Adaptive Clustering Hierarchy protocol should pursue the following sequences:

1. Initially all nodes are homogeneous. The node, which has the maximum remaining energy, advertises itself as the first CH.
2. Then the first CH selects an area, no other node in that particular area can advertise itself as CH.
3. After that another CH is selected from rest of the network. In this way the whole network is divided into some predefined areas.

Each area contains one CH and all the nodes in that areaconstructs a cluster. Thus the CHs are uniformly distributed throughout the network.

Algorithm: UDT

Suppose, number of nodes is *N*, queue Q_N contains all nodes who will perform in the election and queue Q_E contains those nodes that are not going to perform in the election, $E_{i=1}{}^N$ of node *i*, *t* indicates time of rearrangement of CH selection.
Step 1: Initially all nodes are inserted into Q_N, Q_E=null, $CH_i=0$ for all nodes.
Step 2: Set $CH_i=1$ for maximum E_i of Q_N-Q_E
Step 3: Push Q_E all nodes inside $\pi R_{comp}{}^2$ where node i is the center. Node i advertises itself as CH.
Step 4: Go to step 3 until $Q_N \neq NULL$.
Step 5: Each node starts data transmission to CHs and CHs transmit to BS.
Step 6: After t time go to step 1.

For implementation we are using OMNet++ as a simulation tool. OMNeT++ is an object-oriented modular discrete event network simulator. As the simulation part is not yet completed we are still working with this.

Conclusion and Future Works

Routing in sensor networks is a new area of research, with a limited but rapidly growing set of research results. We found that LEACH protocol fails in some conditions where the higher energetic nodes are concentrated, some nodes having highly probable to remain outside of any CH's vicinity will die within short period. Therefore the rotation of cluster heads and the metric of residual energy are not sufficient to balance the energy consumption across the network, CHs are required to be distributed uniformly through out the network so that a single node should not be deducted by clusters. In this paper, we have proposed a uniform distribution technique of CHs selection in order to reduce energy consumption as well as increase nodes life time. The implementation process is still going on using OMNet++ environment. There still some problems for the nodes in overlapping areas. These nodes are needed to choose their own CH and we hope we will solve it by using nearer CH.

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